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THE PSYCHOLOGICAL BULLETIN

A PNEUMOGRAPH FOR INSPIRATION-EXPIRATION RATIOS

BY HAROLD E. BURTT

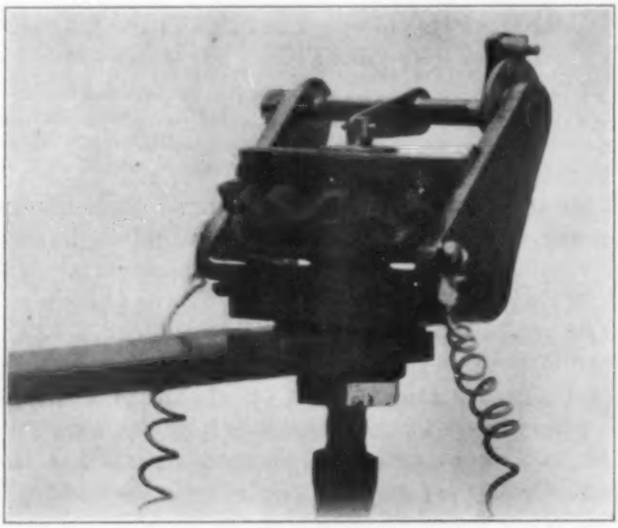
Harvard University

There are many experimental situations in which the principal interest is the relation between inspiration and expiration times. With the usual pneumographic technique the accurate determination of these times is difficult and tedious for the following reasons: (1) the exact peak of the curve must be determined, *i. e.*, the exact point where inspiration or expiration begins; (2) these peaks must be projected onto a horizontal line; (3) the distances between the projected points must be measured carefully (assuming that the kymograph has a constant speed) or compared with a time line. The present method (1) *automatically* records the instant inspiration or expiration begins; (2) obviates the necessity of geometrical projection; (3) eliminates errors in measuring distances or comparing with time lines by incorporating the time record in the breathing record, either on the kymograph or on electric counters.

The crucial part of the apparatus is shown in the accompanying photograph.[1] Its function is to close an electric circuit from the beginning of an inspiration until the beginning of the following expiration or vice versa according to connections. A pneumograph (Sumner's works very well) is connected in the ordinary manner to a tambour. The usual metal disc is glued to the rubber and the lever pivoted to this is fastened rigidly to a shaft. This shaft is pointed for conical bearings, one in an adjusting screw which pro-

[1] The mechanical details of the part illustrated were worked out in the present form mainly by Mr. A. G. Cox.

jects through one side of the base and the other in a piece of fiber (mentioned below). The latter end of the shaft projects through a short arm soldered to it at right angles. On the end of this arm are a silver pin and an ivory (or other non-conducting) pin close together and equidistant from the axis of rotation. A disc with radius slightly less than the distance from the axis of rotation to the two pins is shouldered to bear in a hole in the side of the base opposite the adjusting screw. The disc with its shoulder has a tight-fitting core of fiber. The pointed end of the shaft bears in a hole in the center of this fiber. The disc has a silver pin of diameter slightly



less than the distance between the other two pins projecting between these two pins. Thus as the tambour operates pneumatically the arm with the two pins moves through an arc carrying the disc with it. The shaft with its conical bearings moves very delicately while the disc with its shoulder possesses more friction. The two are insulated by the fiber bearing. The sides of the base are insulated from each other and a wire attached to each. Thus the current enters one base, goes through the adjusting screw, shaft, arm and silver pin on the arm to the other silver pin and out through the disc and other base. The slight friction in the disc enables the silver pins to make a good contact while the tambour moves in one direction. When the tambour starts in the other direction the current is broken, for the disc remains stationary while the arm

moves, but the ivory pin immediately engages the pin on the disc and carries it along so it is ready for another contact when the tambour reverses, regardless of the amplitude or duration of the breath. There is just enough play between the two pins to allow a breaking of the contact. The entire system rotating about the same axis insures a good make and break.

The present piece of apparatus works successfully in the form described. It is possible however that adjustment of the friction in the disc may at some time be necessary. The disc can be shouldered down until it turns too easily and a fine screw threaded into the fiber core from the outside. This screw carries with it a spring washer which will press against the base with any desired force, thus producing a controllable amount of friction. It is very essential that the shaft and arm move very easily and that the disc move as easily as is compatible with its staying in one position when no force but gravity is operating on it. The pressure of the pointed shaft in the center of the core improves the bearing of the disc and the absence of any wires trailing from the moving members is a necessary feature. The apparatus is relatively small,—the tambour being one inch in diameter.

Three methods have been found successful in recording results with the above one-way contact device. The circuit may be led through an ordinary signal magnet, recording on a kymograph. It will trace on one level during inspiration and on another during expiration. The distances mav be measured directly if desired but it is more satisfactory to rivet a light iron disc to the marking lever parallel to the surface of the drum and place a second magnet opposite this with its core perpendicular to the drum. This second magnet is in series with an interrupter (mercury cup, magnet and spring steel vibrator on the door-bell principle) and thus periodically pulls the writing lever away from the smoked surface. There is sufficient spring in the lever to carry it back to the drum when released by the magnet. The lever thus traces a dotted line in, for example, fifths of a second, and by counting dots on the two levels the inspiration-expiration relation can be determined.

A second method which does not require as delicate adjustment and is somewhat easier to read is as follows: The pneumograph circuit operates the magnet of a double relay. Two signal magnets are arranged one above the other to trace on the kymograph. They have one pole in common and the other two are connected to the two outer contacts of the relay while the common armature of the

relay leads to the interrupter circuit. Thus one marker is operating five times a second, *i. e.*, tracing alternately on two levels at that rate, while the relay magnet is open. The other marker does likewise and the first traces an unbroken line when the relay magnet is closed by the pneumograph. To compute inspiration time it is necessary to count the indentations in the line traced by one marker and for the following expiration time count those traced by the other marker. These markers will operate with a relatively rough adjustment against the kymograph, whereas the other arrangement which traces the dotted lines needs careful adjustment and is vitiated by any unevenness in the smoked paper.

A third method is still better if the nature of the experiment is such that the experimenter has to pay little attention to the subject during the actual taking of the breathing record. It consists of substituting for the signal magnets in the preceding method two electric counters.[1] One counter records five numbers a second during inspiration and the other does likewise during expiration. The experimenter writes alternately the readings of the counters during the period when each is stationary. For example, during inspiraation of the subject, the experimenter records the reading of the expiration counter. By subtracting the successive readings in the two columns one has the time in fifths of a second of inspiration and expiration.

These methods make it possible to obtain the inspiration-expiration ratio with considerably more accuracy and considerably less labor than in the ordinary procedure. There is an additional advantage that while the contact arrangement is located conveniently near the subject, the actual recording apparatus can be at any distance, even in another room.

THE LEARNING PROCESS[2]

BY EDWARD K. STRONG, JR.

I. *How Does One Learn?*—Rookies are awkward and know nothing of drill. Later they march and drill with marvelous precision. The fact that such changes occur is so commonplace that

[1] A satisfactory form of counter is made by mounting an armature on the shaft of a "Veeder" counter which registers a digit on a turn of about forty-five degrees. This armature is between the poles of electromagnets, sets itself across the poles when the current flows and is partially rotated by a spiral spring when the current breaks.

[2] Outlines of the Study of Human Actoin for the Students' Army Training Corps, Section 3.

it does not attract our attention. But if we stop to think about it, the whole process challenges our interest. What has occurred so that awkwardness is replaced with skill? The word "drill" does not explain the matter. For constant repetition does not cause a machine to turn out a more and more refined product. Nor does man necessarily become more and more accurate in his movements through continued repetition. Frank B. Gilbreth has shown us that the average bricklayer today lays 120 bricks per hour—a rate which has probably not increased at all for generations despite the fact that millions of men have practised the trade. But such a bricklayer can lay 350 bricks per hour and moreover be less fatigued at the end of the day. Gilbreth has reduced the motions of a bricklayer from 18 to 5, principally through having the helper supply the bricks in a more convenient manner and at the height of the bricklayer's belt. In this way the effort of lowering one's body down two feet and raising it up again every time a brick (weighing 5 pounds) is laid in the wall is eliminated. Here there has been something added besides mere repetition (drill) which has greatly increased the proficiency of the worker. What was it?

To throw some light on this subject, carry out the following very simple experiment. Be careful to execute the instructions as given.

Call upon your room mate to recite the alphabet as rapidly as possible. Time him and record the number of seconds. Also note any mistakes made. Repeat this for ten times. Now call upon him to recite the alphabet backwards, timing him each time and recording his mistakes as well as you can. (It is well in both cases to have the alphabet written out before you so that your eye can follow his progress: mistakes are thus more easily detected and recorded.)

Now plot your data on coördinate paper. Along the base line, number equal steps from 0, 1, 2, etc., up to 10, representing the ten successive trials. Along the vertical axis number equal steps from 0 up to the longest time recorded in saying the alphabet backwards. Zero of each scale should be at the lower left hand corner of your chart. Plot the data from the two ezperiments.

Now write out your answers to the following questions.

(1) How do your two learning curves agree? (Note down all agreements, however trivial they may seem.) Explain. (2) How do your two learning curves differ? Explain why. (3) What other changes took place besides those of increasing speed? To what

extent were they important factors in the learning? (4) The command has been the same in each experiment, being, "Now, recite the alphabet," or "Now, recite the alphabet backwards." In other words, the *situation* confronting your room mate was the same, but his *response* differed each time. How can you explain the change? (5) If you could secure a record of the time required and number of mistakes made each time you respond to the command (situation) "Right shoulder arms" would you get a similar record to that of saying the alphabet backwards? Explain. (6) Is it natural to expect noticeable progress the first few times one does any new performance and then less and less progress until the progress becomes too slight to be noticed? Is there any relationship between such a phenomenon and loss of morale when troops are kept in camp a long time? Prepare to hand in this exercise at the next class hour.

II. *Why do Recruits Fluctuate between Well and Poorly Executed Movements While Learning?*—If we watch a recruit "right shoulder arms" we will notice one time he does exceedingly well and possibly the next ten times he will do poorly, only to surprise us again with a well executed movement. Later on he will ordinarily do well but from time to time lapse into a poorly executed performance. Is this the natural course of events or is it due to the way he has been taught and is handled?

In the previous part we discovered some facts which are fundamental to all learning. Note how they hold true as you master such commands as "About face," "Squads right," "Present arms," etc. In order to get a clearer idea of other principles underlying such performances carry out the following.

Lay off on a piece of paper two parallel lines eleven inches long and one inch apart. Draw cross lines an inch apart, so as to have eleven one-inch squares. Place five nickels on the five squares at the extreme left and five cents on the five squares to the right, thus leaving the middle square uncovered. So move the coins that eventually they will have exchanged places. A coin may only be moved forwards or jumped over a single coin of the other kind. Solve this puzzle twenty times. Have your room mate record the time consumed for each solution and the number of false moves made. (There is no catch to the puzzle: it can be solved in a few seconds.)

This puzzle is a comparable situation to that confronting the

average auto driver when his car goes dead, or to the learning of complicated military manœuvres, or to the inventor's struggles to invent a new method of combating the U-boats.

Plot the learning curve. Write out the answers to the following questions.

(1) How does this learning curve compare with those secured in learning the alphabet? Explain. (2) Why did you again and again make the same identical mistake? (3) How did you come to solve the puzzle? Did you see the correct move and then make it, or vice versa? (4) In teaching the manual of arms should one emphasize speed or accuracy at the beginning? (5) After solving the puzzle 1,000 times, if you then recorded the time of the next 20 trials, how would that curve differ from the curve of your first 20 trials? (6) Is there a limit beyond which you cannot go as to speed and accuracy regardless of the amount of drill? (7) Is it natural to expect awkward movements in drill at the start and content one's self with progress from them to orderly execution, or could one secure correct movements from the start through careful teaching? Hand in your report at the next class hour.

III. *What Relation does Losing One's Temper, etc., Bear to Learning?*—We have all seen individuals lose their temper. They sometimes use unnecessarily vigorous language, and may even kick some object with which they had been tinkering because they could not fix it. Too often we see executives, including officers, lose their temper when men under them do not execute their commands. And on the other hand we see subordinates become sullen and stubborn or openly defiant when being instructed in some new performance. Why do men lose their temper at such times? Is there any relationship between learning and annoyance, exasperation and explosive action? If so, can learning be so carried on that there will be no outbursts of temper? Or is it possible that anger is advantageous in learning?

We can distinguish here between (1) one's attitude toward his work, one's feeling, and (2) one's method or "mode of attack" in the work.

Ruger in *The Psychology of Efficiency* (pp. 36–39) calls attention to three different general attitudes toward one's work. He calls them (1) The self-attentive attitude, (2) the suggestible attitude, and (3) the problem attitude. The *self-attentive attitude* is illustrated by him by this extract from a man's account of how he solved a puzzle.

"It seemed to me that if anybody had given it to me without saying that it was a puzzle (a bona fide one) I would have said it was impossible up to the last minute. I have a feeling now of loss of esteem. I had this all along because I couldn't do something which was made for people with ordinary brains to do. One conclusion that kept running through my mind all the time was that I had a subordinate mind. I couldn't help having a gleeful, self-satisfied feeling when it actually seemed to be coming off, although it was a surprise."

Individuals possessed with this self-attentive attitude express themselves as being afraid that the experimenter was getting bored because they were slow, or that he would think them extremely stupid, etc. The principal thing, then, that occupied the minds of people with this attitude was the concern as to their general fitness and as to what others would think of them.

The Suggestible Attitude.—Ruger says, "In two of the men there seemed to be a special sensitiveness towards any movements of the operator which might give an indication as to the course to be pursued. In such cases as this there is a lack of confidence in the self but the attention is directed not to the self but to some other person. The center of gravity, if one may so describe it, of the responsibility is located elsewhere and the suggestions, intentional or unintentional, of the other person or persons concerned are accepted uncritically. This tendency was noted by the writer in his own case in novel situations of a more distinctly social type, such as business transactions of an unaccustomed sort, or other similar cases where persons instead of things were to be dealt with and where the other person was felt to have superior information as to the matter in hand and the self to be deficient."

Probably all have experienced this attitude when attempting to do something new while in the presence of others. This is particularly true when those present are known to know more about the task than one's self. Their presence bothers us; very often we make mistakes that we know we would not make if we had been alone. Here our attention is directed as much, if not more, toward those who are present than to the work before us. And at such times we are especially susceptible to any indications from these persons as to whether we are doing well or poorly.

The Problem Attitude.—"In contradistinction to these two attitudes, which are certainly not favorable to efficiency," this third attitude is essentially an attitude of self-confidence. "The self-

confidence is not one of sluggish complacency, however, but is expressed in a high level of intellectual activity, of attention. Attention would be directed to the thing to be done rather than to appraisal of the self."

In experiment of the last lesson undoubtedly most individuals had somewhat of the self-attentive attitude, or the suggestible attitude, or both to start with. And as practise continued the earlier attitude faded out more and more and the problem attitude took its place. Occasionally an individual displays only the problem attitude throughout the practice period. And occasionally also an individual continues to show the self-attentive attitude throughout, but this is rather rare. Usually there is a noticeable change toward the adoption of the problem attitude.

Some of the factors that bring about this change in attitude are the realization that one is improving, that one can do the task, that another is doing it successfully, etc. But sometimes the latter factor reacts in just the opposite way.

Differences in Feeling.—For our purpose here in an elementary course we can think of feeling as either pleasant or unpleasant. If either become particularly strong then we have an emotion of joy or love on the one hand, or fear, hate, or anger on the other hand.

Now repeat the experiment of the nickels and cents with another person and note carefully all evidences of changes in attitude or feeling or emotion during the experiment. Determine as carefully as possible the relationship between successful or unsuccessful moves and feeling. Also note whether the person doing the puzzle changed his method or "mode of attack." If so, just how were these changes associated with changes in attitude or feeling?

Carefully consider the type of situation involved in this puzzle, or in learning signaling, or in fixing an auto engine with such other situations as writing up reports, or reading orders, or performing military manœuvres after they have been learned. Explosive action is much more likely to occur with the former than the latter. Why?

From a practical standpoint, when we find a man losing his temper or acting in a sullen and defiant way what should we guess is the matter? How should we go to work to correct the trouble? Is disciplinary action the proper method to accomplish this?

What are the best steps to take to cure a capable man of self-consciousness and make him a good leader of men?

Write up your report discussing at length your conclusions on these points—particularly as to the practical applications affecting the relationship between officers and soldiers.

IV. *How Should a Command like "Squads Right" be Taught Recruits?*—Just how does one learn to execute "right shoulder arms" or to shoot a rifle accurately, or salute properly, or any of the many new movements involved in military training? An accurate analysis will show that there are really two fundamentally different methods.

With the first method one just stumbles about trying this and that and eventually after being corrected again and again finally succeeds in executing the movement satisfactorily. This procedure can be illustrated roughly in this way. Suppose P and Q, who are blindfolded, are standing in the middle of a recently harrowed field, or better still in a field covered with snow. P determines just to which part of the field he wants Q to go but he doesn't tell him: Q is to reach this point by keeping walking, changing his direction whenever P calls out "Change" and to keep going when P says nothing. Now when Q starts out he is as likely to go one way as another. The consequence is that he will start a number of times and because they are wrong P will so signal and Q will stop and start again. The snow all about the starting point will become all trampled because of these starts and stops. But presently Q will hit upon the correct direction, P will no longer signal to stop and Q will continue in the desired direction. If he walks in a straight line he will presently reach the desired point. If he doesn't P will signal to change and Q will than make a few stops and starts, finally hitting on the correct direction again. In this way Q will finally reach the desired point. He has reached it through starting many incorrect movements which were immediately checked and then continuing the correct movement whenever hit upon. Now suppose P and Q start over again. The process will be largely the same as before. But as it will be easier walking wherever Q has traveled before, Q will be much more likely to continue in old paths than to make new ones. And as the correct direction is the only one that continues for any distance Q will be aided by it much more than by the little short paths that lead in the wrong direction. Still on the second trial, Q's guidance will come essentially from P's signals. As P and Q keep up this stunt, the correct path will become better and better formed and Q will gradually come to rely on it more and more and to need P's signals less and less. After a certain number of trials it is likely that Q could traverse the distance with no mistakes, by utilizing the well-worn pathway as a guide instead of the signals of P.

Much of our learning is of this sort, called in psychology "trial and error" learning. It depends (*a*) upon the teacher correcting us when we go wrong and encouraging us to keep at it when we go right and (*b*) upon the development of pathways, which popularly we speak of as "habits." In some way or other not understood today, the repetition of a series of movements creates certain pathways in the brain so that nervous discharges flow more easily over them than over new pathways.

Such learning always results in decided fluctuations in the speed and accuracy of each execution. One moment the act is beautifully performed, the next it is wretchedly carried out. But if the teacher constantly corrects and encourages there is improvement from day to day. Good instruction in this connection, however, is about as fatiguing for the instructor as for the learner; and too many instructors cease too early in their efforts, this resulting in ragged performance on the part of their pupils. Observation in most camps of the great variety of ways in which the act of saluting is done indicates how little real attention has been given to this very simple performance by the instructor.

The second method of learning, as distinguished from "trial and error" learning, is based upon analysis. In executing "right shoulder arms," for example, there are a number of simple movements with each arm. If the instructor analyzes out exactly each movement and then calls upon the squad to make movement No. 1 and sees to it that all clearly comprehend it and make it, then does the same with movement No. 2, and so on to the end, he will succeed in teaching the entire performance much quicker and with greater accuracy. Here the learner first of all notes the specific movements to be made and second he learns the order in which they are to be made.

Learning through analysis differs from learning by trial and error in that in the first case we "spot" the successive steps and then do them, whereas in the second case we stumble around with our attention on getting the whole process finished and possibly never do get clearly in mind how we do it.

Successful teaching in the army or elsewhere is dependent upon a careful analysis of each step in the whole process, the presenting of one step at a time, and finally sufficient drill upon the whole process so that all the steps are welded into one smoothly executed act.

Assignments.—Work out in as definite and detailed a way as

possible just what one does when (1) he salutes a superior office, (2) he "about faces," and (3) a squad executes "squads right."

V. *How do Individuals Differ in Their Learning?*—In preceding lessons we have seen that individuals differ in many respects. One of the most important ways, however, in which individuals differ has not yet been discussed, *i. e.*, how they differ in their rate of learning.

In Figure 1 is shown the learning curves of two 10-year-old girls in solving simple addition combination, such as, $\begin{array}{r}4\\ \underline{3}\end{array}$, $\begin{array}{r}7\\ \underline{1}\end{array}$, $\begin{array}{r}8\\ \underline{4}\end{array}$, etc. The first girl solved 10 such problems correctly in one minute on the first day and on the twentieth day solved 37 correctly. The second girl solved 5 on the first day and only 9 on the last day. These are two extreme cases, it is true, for the first girl was one of the brightest in the 4th Grade while the other was mentally defective and still in the 1st Grade. Nevertheless the curves illustrate what we find throughout life, *i. e.*, the brighter the child the faster he learns; the duller the child, the slower he learns.

Probably everyone will agree to the above statement. But many will go on to add that the slow learner remembers longer and better than the fast learner. The proverb, "Easy come, easy go" is often repeated in such connections. Modern psychology has demonstrated, however, that popular opinion is in this case incorrect, that the rapid learner, on the average retains what he learns much longer and more accurately than the slow learner. The following figures are typical.

NUMBER OF PROBLEMS SOLVED

	At Commencement of Practice	At End of 10 Practice Periods	Gain in Number of Problems
College students	59	76	17
4th grade children	19	30	11
Defective children	4	7	3

Stated in another way the data shows us that

College students excel 4th Grade children at the start by 40 problems.
" " " " " " " " end " 46 "
College students excel Defective children at the start by 55 problems.
" " " " " " " end " 69 "
4th Grade children excel Defective children at the start by 15 problems.
" " " " " " " " end " 23 "

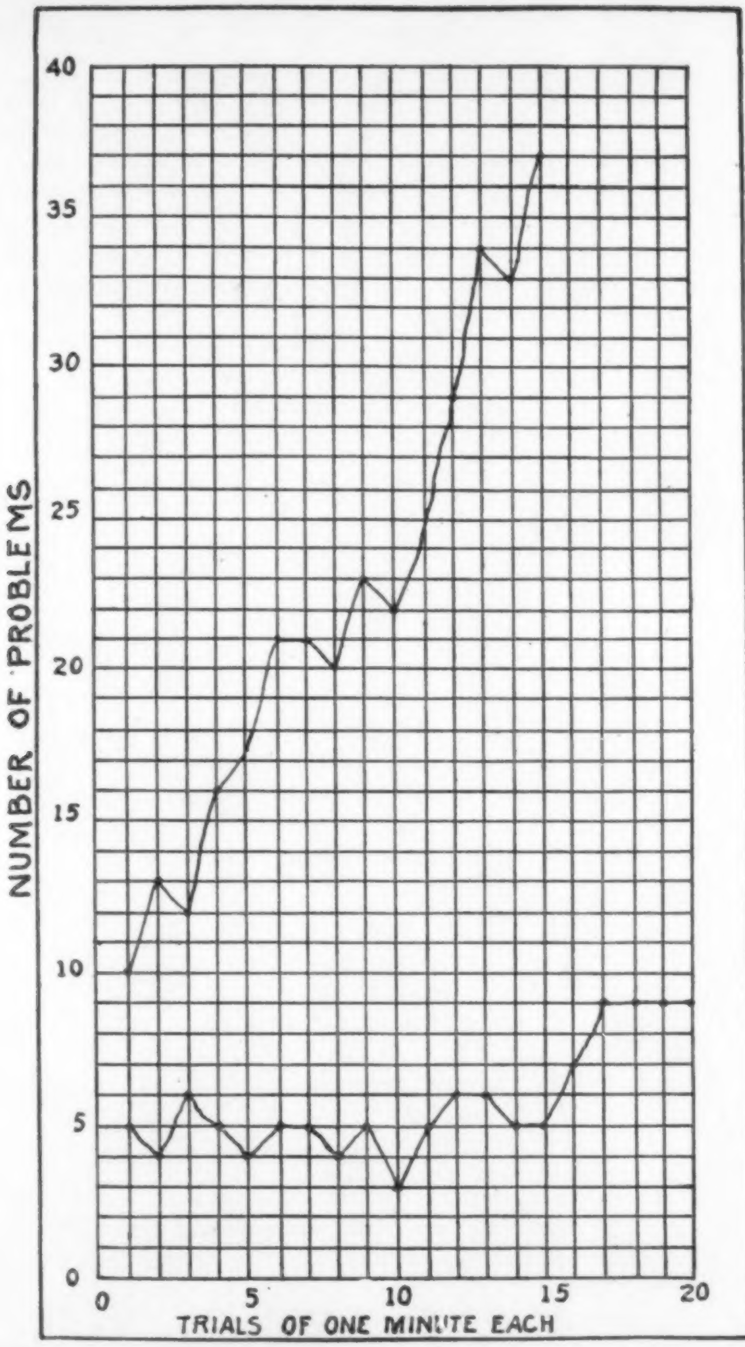


FIG. 1. Showing learning curve in solving addition combinations for a bright 4th grade child and mentally defective child of the same age. (In case of the latter between trials 10 and 11 there intervened 170 minutes of drill extending over 25 days on addition combinations.)

Of course, there are some rapid learners who don't spend enough time on their work really to learn it and who consequently very quickly forget and there are some slow learners who spend a great deal of extra time on their work and do remember it very well. But these are the exceptions to the rule. The brighter the individual the quicker he learns and because he is bright he also retains best. The duller the individual the slower he learns and just because he is dull he forgets quickly.

The psychological intelligence rating, discussed in Section II, is a fairly good measure of the rate at which one will learn a new thing. In consequence one should expect that rating A and B men will learn rapidly while rating D and E men will learn very slowly. The former will get in one or two lessons what the latter will only get in three or four, or even more lessons.

Another way of presenting these facts is this. Suppose A is bright and can get his lessons in two hours' study whereas B is not so bright and can get his lessons only after four hours' work. Now if both get each lesson as they go along, of course, they will both finish the course. If B, however, can only give three hours to his lesson, then he will get but three-fourths of the first lesson. In the case of the second lesson he will get less than three-fourths, for not knowing one-fourth of the first lesson will make it still harder to get the second. In a very short time he will be unable to get the lessons at all, even devoting three hours to them, because so much of what has gone before is unknown to him.

All of this actually happens in every college every year and in the army in Officer Training Schools and in company drill. The proper handling of such failures in most cases is to take them out of the group and give them separate instruction with a clear recognition that they will progress but at a slower rate than their brighter companions.

Assignment.—(1) Outline what use the psychological ratings can be put to in the training of a company of infantry. (2) What additional steps should be taken in order to secure as well balanced training as is possible for an infantry company? (3) What treatmen should be accorded (*a*) an intelligent man who is sullen and slow in learning signaling? (*b*) an unintelligent man who is sullen and slow in learning signaling?

VI. *How can Forgetting and Fatigue be best Overcome?*—From the *New York Times* of about May first, 1914, is quoted the following editorial comment on an article by a superintendent of a Connecticut brass works which appeared in *The Iron Age.*

"At these works there was recently constructed a long incline up which heavy loads were to be wheeled in barrows, and premiums were offered to the men who did or exceeded a certain amount of this labor. They attempted it vigorously, but none succeeded in earning any of the extra money, instead they all fell considerably below the fixed task.

"Prompt investigation by an expert disclosed that the trouble lay in the fact that the men were working without sufficiently frequent periods of rest. Thereupon a foreman was stationed by a clock, and every twelve minutes he blew a whistle. At the sound every barrowman stopped where he was, sat down on his barrow, and rested for three minutes. The first hour after that was done showed a remarkable change for the better in accomplishment; the second day the men all made the premium allowance by doing more than what had been too much; and on the third day the minimum compensation had arisen, on the average, 40 per cent., with no complaints of overdriving from any of the force."

Apparently a man can do more physical labor by working 12 minutes and resting 3 minutes out of every 15 than he can if he works all of every 15-minute period throughout the day. This principle is one of the fundamental principles underlying scientific management, which has been so much discussed of late in various publications.

This statement raises an important issue: how shall an officer distribute his time in drilling his soldiers so that thev will learn most rapidly. Certain factors enter into such a problem: (1) the laws of learning; (2) the laws of forgetting; (3) the laws of fatigue; and (4) the effect of rest periods upon learning and fatigue.

The laws of learning have been already presented sufficiently for our purpose here. One learns rapidly at first and then more and more slowly; one fluctuates from moment to moment as regards accuracy and speed of performance; one learns in proportion to one's intelligence; etc.

The principal law of forgetting is that what we have learned is always being erased from our minds and that we forget most of a new lesson very quickly and the remainder more and more slowly. In consequence, each day before we can start to learn new things we must re-learn what we learned yesterday but have since forgotten. This relearning is spoken of as "warming up." All engaged in athletics know how important warming up is before one enters a contest. We don't appreciate the fact so much in the more purely

intellectual realm, but the law holds good just the same. One hour spent on a lesson during the evening and reviewed for fifteen minutes in the morning will be recited upon much better than if an hour and a quarter is spent upon it at night. And if a company was quietly and slowly put through all the movements which it has recently learned during the first few minutes of drill in the morning, much greater progress would be made with far less confusion. For it is useless to expect a company to drill the first thing in the morning as well as it did the preceding day.

The principal law of fatigue is that theoretically we commence to fatigue as soon as we start working, but practically we do not commence to slow up or do poorer work until after working some time. The difference is due to the fact that for sometime we shift the work from one set of muscles to another thereby resting them in turn and only after they are considerably fatigued does the performance actually show a diminution in work done.

With these facts before us we are ready to consider situations such as presented in the illustration taken from the *Iron Age*.

Professor Starch had four groups of individuals employed in a

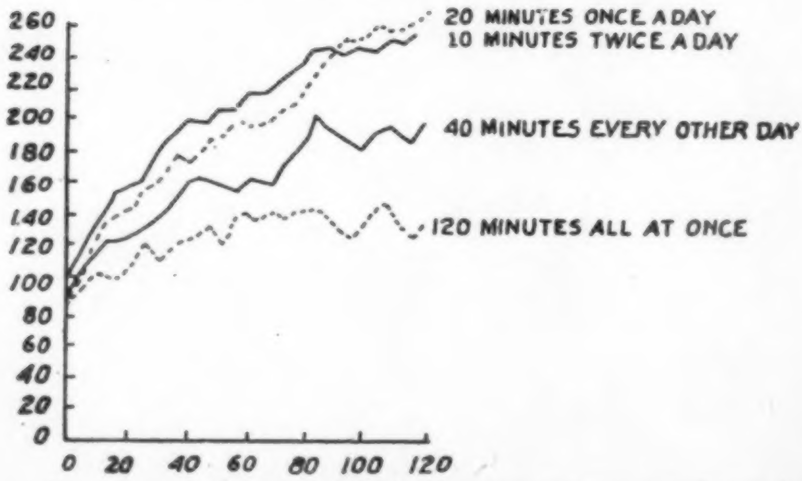


FIG. 2. Showing improvement in writing numbers for letters, according as the total time of 120 minutes is distributed in four different ways. Based on work of Starch.

substitution test for a period of 120 minutes each. (A substitution test is similar to the process of transcribing a letter into a secret code.) The first group worked 10 minutes at a time, twice

a day for 6 days; the second group 20 minutes at a time once a day for 6 days; the third group 40 minutes on alternate days and the fourth group worked 120 minutes at a stretch. From Figure 2, it is apparent that the first group accomplished the most, with the second group a close second. Both groups accomplished considerably more than the other two groups.

The writer drilled a fourth grade two minutes a day in addition and multiplication each day for 14 days and found the following average number of simple problems done on the 14 days,—the problems consisting of the combinations from $\frac{0}{1}$ to $\frac{12}{12}$.

	Addition	*Multiplication*
1st	38 problems done correctly	22 problems done correctly
14th	66 " " "	55 " " "

No one could duplicate such rapid improvement if they spent 28 minutes on either addition or multiplication all on one day.

As a general answer to the problem set us in this lesson, we can say that *distributed learning*, *i. e.*, learning periods interspersed with rest periods, *is superior to concentrated learning*. Ordinarily the difference between the two methods is considerable.

These examples illustrate the effect of rest periods in learning. There is no evidence, of which the writer is aware, that such distributed periods are superior to steady work when the individual is *working* as distinguished from *learning*, up to the point where fatigue commences to be manifested. Work involving fatigue can,

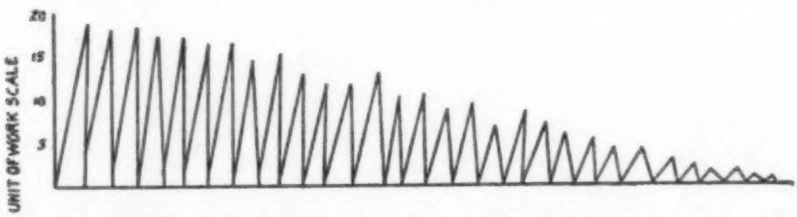


Fig. 3. Showing fatigue from work. The height of the successive lines shows the amount of work done with each contraction.

on the other hand, undoubtedly be facilitated by distributing the work periods, *i. e.*, by distributing work and rest periods throughout the day. One example of this has been presented at the beginning of the lesson.

Maggiora has shown that if 30 contractions exhaust a muscle so that it needs 2 hours rest in order to do equally efficient work

again, 15 contractions will require not 1 hour's rest but only ½ hour's rest for recuperation. The second 15 contractions exhaust the muscles, then, very much more than did the first 15 contractions. At the same time the amount of work accomplished by the last 15 contractions is much less (as can be seen from Figure 3) than that accomplished by the first 15 contractions. Roughly to illustrate this, suppose the first contraction does 20 units of work, the 15th contraction 10 units and the 30th contraction 0 units. Then the first 15 contractions would do $(20 + 10 \times 15)/2$, *i. e.*, 225 units of work and the last 15 contractions would do $(10 + 0 \times 15)/2$, *i. e.*, 75 units of work. Now if A should do 15 contractions and then rest 30 minutes alternately for 8 hours, he could do (16×225), *i. e.*, 3,600 units of work, whereas, B who did 30 contractions and then had to stop for 2 hours in order to be rested—could do $(4 \times (225 + 75))$, *i. e.*, 1,200 units of work. A so worked that he never became particularly fatigued and he only worked while he was doing efficient work (*i. e.*, the first 15 contractions). B, on the other hand, kept working until exhausted and then had to rest a long time. By so working he also did inefficient work (*i. e.*, the last 15 contractions).

Work can be explained as resulting from chemical changes causing movements of the muscles. Glycogen ($C_6H_{10}O_5$), the form in which digested sugar is stored in the body, disappears. And carbon dioxide (CO_2), lactic acid ($C_3H_6O_3$), and acid potassium phosphate (KH_2PO_4) are liberated. Continued excessive work results in the glycogen being used up faster than it can be brought to the working muscles by the blood. Also, the waste products accumulate in the muscles instead of being carried away by the blood. A rest period provides an opportunity for needed glycogen to be brought to the muscles and the waste products removed.

With all these facts before us it is clear that the alternation of work and rest periods secures to the worker his maximum output since his muscles never become clogged with poisonous waste products and they always are supplied with sufficient glycogen. The proper ratio of work and rest will depend, of course, on the type of work to be done. Excessively hard work will require relatively more frequent and longer rest periods than more moderate work. In cases of light work, it has been found advantageous to have the workers work at top speed for short intervals and then rest, advantageous from the standpoint of work accomplished and interest and lack of fatigue on the part of the worker. Most individuals

become more wearied by the monotony of an easy task than by the work itself. Frequent rest periods break up this feeling of ennui, especially when during the working period the work is done at such a rate as to demand one's full attention.

Assignment. (1) What is the effect of cramming? (2) What happens when a company is drilled too hard? (3) What is the most efficient manner of studying? (4) What Army regulations provide for the interspersing of rest periods in drill and in marching?

GENERAL REVIEWS AND SUMMARIES

REACTION TIME

BY V. A. C. HENMON

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Cassel and Dallenbach (1) studied the effect of continuous (an electrically driven tuning fork), intermittent (electric bell), and continuous-intermittent (metronome) auditory distractions upon sensory reactions to auditory stimuli (noise produced by the Wundt sound-hammer). The lengthening of reaction times under distractions on the average is smallest in the case of continuous distraction and largest in the case of intermittent distraction, which leads to the conclusion "that the 'inhibiting' effect of a distraction varies with its duration and regularity." A detailed analysis of the data, however, shows the effect of the distractors is not uniform, it may inhibit or may facilitate the reaction or it may become habitual and have no effect at all. The effect of the distraction is dependent not only upon the temporal relations of the distractor but also upon the conscious attitude of the observer during the distraction. To neglect of standardizing the observer's attitude is attributable the lack of agreement among previous investigators.

May (4) studied the processes involved in the fore-period, main-period, and after-period of the controlled associative reaction with special reference to the analysis of the fore-period. The hypothesis on which the study proceeds is that the significant thing in controlled association is not what takes place between the stimulus and the response, that is, in the main-period, but what takes place just before the stimulus is given, that is, in the fore-period. Introspective observations and time measurements were taken with stimuli requiring the subject to give (1) opposites, (2) whole-parts, (3) part-wholes, (4) subordinates and (5) verb-objects, with variations in times of the fore-period of .88, .50, .35, .15 and no seconds. The time measurements centered about the relation between the length of the fore-period and the length of the main-period. The results show that complete preparatory set shortens the association time from about 10 to 25 per cent. The total time of the entire

performance is shortest, however, when the preparatory set is at ts minimum.

Richmond (5) urges the use of the reaction key suspended as a pendulum instead of on a spring and employing the opposition of the thumb and fingers in producing the reaction movement. The key is closed by placing the finger on the button and the thumb on the base. By simply opening the thumb and finger the key is released. The horizontal motion makes this use of the key better than the Dessoir key as modified by Scripture. The suspended key, it is claimed, reduces the number of muscles used in making the response movement to the fewest possible, and apparently eliminates the antagonistic reactions.

Klopsteg (3) describes a chronoscope which consists of a galvanometer with a direct reading scale, corresponding to the intervals during which a steady current is permitted to flow through the instrument. "The calibration of the scale depends upon the known relation between the total quantity of electricity which has passed through the galvanometer during a given time interval, and the length of this interval. As a means of adjustment and control of the scale readings, a new fall apparatus is described which accurately "measures out" to the chronoscope any time interval within the range of the latter." The advantages of the chronoscope are simplicity and ease of manipulation, great accuracy, absolute silence during operation, automatic return of indicator to zero reading, and hence rapidity of operation.

Claparède (2) describes an apparatus constructed by M. Dégallier which may be used as a chronoscope, as a chronograph, as an electric counter, or to give periodic signals. The chronoscope is light and portable, measures very accurately to hundredths of seconds, and according to Claparède has many advantages over the D'Arsonval or Hipp chronoscopes. The manufacturers are Les Fabriques des Montres Zènith, au Locle, Neuchâtel, Switzerland.

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LEARNING

BY F. A. C. PERRIN

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A detailed and forceful criticism of the accepted normal learning curve is made by Peterson (7). This criticism is the result both of a rearrangement of data that have been furnished in the past by Bryan and Harter, Swift, etc., and of experiments in ball tossing conducted by the writer. Peterson believes that erroneous conclusions regarding the learning curve have been accepted because of failure on the part of investigators to study the significance of the data upon which the curve is usually based; particularly the failure to distinguish between (*a*) curves of average attainment, or accomplishment curves and (*b*) time, error or excess distance curves—the ones usually plotted by investigators. This specific failure has led to unwarranted comparisons between these two curve types. The author's first and chief contention is concerned with the rapid initial slope commonly described. Little evidence exists, so far as ball tossing is concerned, for the current view that learning is more rapid in its initial stage; in fact, the evidence for this phenomenon in most learning activities is of doubtful value. The reciprocal relationship existing between the attainment curve and the error curve is the explanation for the misleading inferences made. It is such that the error curve must drop comparatively very rapidly at first while the attainment curve changes very slowly; and the error curve must drop very slowly later while the attainment curve rises rapidly. These changes do not indicate corresponding changes in the learning. The second criticism is directed at the usual discussion of the plateau and the approach to the physiological limit. Whether or not a plateau appears depends upon the type of curve chosen to represent the learning process. If it comes late in the learning, it may be covered up in the time or error curve; and this may be one reason why time and error curves frequently fail to show plateaus. A third point is the distinction between motor learning and sensory discrimination learning. The latter is characterized by the absence of the initial slope and plateaus. A proper conversion of the data would show little grounds for the distinction —*i. e.*, the true motor learning curve would approximate the sensory discrimination curve. In addition to the critical discussion of the learning curve, several conclusions are offered regarding some of

the difficulties involved in the study of learning. Practice in the early part differs so much from practice in the later part that comparisons can scarcely be made. The skilled juggler during a ten-minute practice and the beginner during an equal time practice actually are engaged with separate problems.

An experimental contribution to the curve of mental work is made by Starch and Ash (8). A distinction should be made between the method involving tests or measurements at the beginning or end of periods of work (or at intervals during the work) and the method of investigating the progress of the work itself. In the first, the plan is to eliminate such factors as practice, warming up, etc. In the second, these factors are accounted for and evaluated. The present investigators followed the second procedure, using mental computation as the function to be studied. The subject was given a number consisting of two digits, and was instructed to add mentally six to this number, then seven to the sum, then eight and nine in order to the cumulated sums; he was then to return to six, add it to the sum last obtained, and continue this process in rotation, announcing his results orally. At the end of each thirty second interval the experimenter announced a new starting number. Twenty-three subjects were used. The length of the periods varied from thirty minutes to two hours and a half. This technique was employed for several reasons: it reduced sensory and physical factors to a minimum, it was continuous and homogeneous work and it taxed mental effort to its fullest extent. A record was kept of the amount and accuracy of the work accomplished. The results show that the maximum speed is attained by the end of the first twenty-five or thirty-five minutes and that during this period the improvement is gradual. This maximum speed is maintained during another thirty or thirty-five minutes. From the end of this stage the number of additions per unit of time begins to decrease gradually and continues to do so until the end of the period. Irregularity is most pronounced when the rate of addition is highest. In order to determine the full significance of this fact, the experimenters divided the data into two groups. Records averaging more than twelve additions for each half minute were put into Group I; records below that number, into Group II. This brought out the additional facts that those who work rapidly are more accurate; and, that a longer time is required to make an incorrect addition than a correct one, irrespective of the general speed of the worker. Conclusions regarding the analysis and function of mental fatigue are suggested

by the data. It was found that there are fewer errors at the close of the period of work than at the beginning. Mental fatigue is in one respect comparable with physical fatigue: as a muscle becomes fatigued, resistance developes in the nerve tract leading to it and the resistance protects the muscle from complete exhaustion. At the beginning of mental work the mind is alert and ready to respond to suggestions, extraneous and otherwise; towards the close of an extended period of mental work it becomes insulated to impressions and intrusions. In mental addition the associations called for are old and well formed. They persevere during fatigue while more recent associations tend to become eliminated. Hence the greater efficiency after a certain duration of practice. However, when an error finally does occur, it is followed be several others, and this tendency increases as the work is continued in its final stage.

A study made by Chapman on the effect of rapid changes of work on the rate of performance is of interest, especially when compared with the article just reviewed (2). Chapman's problem was to study the effect of rapid changes of work (*a*) when only one operation was performed and (*b*) when two operations were performed alternately. The efficiency of a group of subjects was tested during five different periods. In each of these periods the work was divided into six trials, each in turn of three minutes. During each of the three minute trials the work was interrupted every half minute, resulting (*a*) either in one kind of work, halted every half minute but immediately resumed or (*b*) alternate half minutes of two different kinds of work. The two types of work were addition and cancellation. The Thorndike addition and the Woodworth-Wells cancellation blanks were employed. When the work was alternated, the subject was given a blank containing the two sets of work on the two sides of the sheet; when the work was of the same kind, the sheet contained the same type of material on both sides, but the subject reversed his paper at the stated times. As the result of this experiment it was found that addition is fourteen per cent. more efficient when it is alternated with cancellation, but in the cancellation operation the effect of the change of work is negligible. This phenomenon can not be explained in terms of interest. It is probably a matter of interference. Cancellation is chiefly a motor test, and in the case of continuous performance the previous cancellations do not require time in order to fade away. Little has to be banished from the mind when the subject proceeds to the next cancellation. In contrast with this, addition is primarily a mental function.

When a transition is made from one problem to another all previous results, except the one necessary for the immediate calculation, must be forgotten. An individual with no figures in his mind can go faster; time therefore must be given for previous figures to fade out. In an extension of the experiment, half minute periods of rest were alternated with similar periods of addition. The increase in efficiency was found to be even stronger—twenty-one per cent. The conclusion reached by Chapman is in harmony with the results of an investigation previously conducted by him. Initial spurt is a negative term. It is due to lack of interference from antecedent mental work, rather than to a greater intial effort.

Two articles by Pechstein deal with the problem of the whole vs. the part method in motor learning. The first and major one (5) is a comparative study, giving the results of a extensive investigation of the maze learning behavior of the white rat and human. The problem is introduced by a concise statement of investigations previously made by various writers. Investigations have been limited to logical and rote material; they have been concerned with whole and part methods, but with no modification of either. Moreover, of the several explanations offered for the waste in part learning, none have been tested under controlled conditions. Pechstein's complete program was (*a*) to determine whether whole and part results in logical and rote learning hold for sensory-motor adaptive situations (*b*) to determine whether these laws hold for animals as well as for humans (*c*) to determine what factors operate for economy or waste in these methods (*d*) to devise new methods superior to either the whole or the part method (*e*) to apply the results to the school child. An ingenious maze was constructed for the white rat. It contained removable panels so arranged that the four sectors in the maze could be learned in any order. These four sectors were made equal as regards the number of possible errors and the length of the true path. A second maze was designed as a check upon one phase of the problem. Two corresponding pencil mazes for humans were employed. The results of the first part of the investigation indicate that the whole method brings final success with fewer trials than the part method, for both rats and humans, but with a greater percentage of gains for the humans. But while rats save time and errors by the part method, humans do not. The explanation is to be found in the retracing; that is, in the tendency to score errors while going towards the entrance. If these were eliminated from the records, the whole method would prove superior for both rats

and humans in every respect. Pechstein's second specific problem was the investigation of the retracings. Since these could not be entirely eliminated, he prevented a return into any of the four units of the maze after the preceding unit had been traversed. It was found that for both humans and animals the prevention of the returns increases the number of trials necessary for complete mastery, but with an enormous saving of time and errors. This discovery led to a discussion of the elements of waste in part learning. Five possible explanations have been proven to be unsound: (*a*) the loss in the part method is not due to negative transfer, since the evidence establishes the fact of positive transfer—learning one unit is favorable for the mastery of a subsequent unit. (*b*) The second hypothesis, that the loss is due to disintegration through time, is rejected on the experimental evidence. (*c*) No retroactive inhibition is exerted upon motor habits by the learning of subsequent ones. (*d*) The explanation of contiguity of unit functioning does not suffice for the loss in the part method. No new sequence of the four units (traversed as units) in the maze results in an appreciable loss. The part learner has absolute control over all of the units he has mastered, provided that these are kept as units. (*e*) A final explanation, that of unit incompatibility in a larger series, is likewise not supported by facts. A motor unit can function as such when it is part of a larger whole, and no incompatibility between specific parts exists in a motor problem. The hypothesis that does account successfully for the waste in part learning is that of place associations. Place association is the referring of an element in a problem to the entire problem. Thus, in rote learning a given syllable is learned with reference to the entire antecedent and subsequent terms. The maze learner relates a certain time span, distance and path sequence with a change in activity, such as feeding, in the case of the rats. In the part method the learner attacks his problem with the expectation of having it solved when certain time, distance and path sequence demands have been satisfied. The readjustment necessary in combining new units, as shown by the behavior in the act of connection, explains the loss in part method learning. However, it must not be inferred that the whole method is the efficient alternative, since modified part methods are superior to the pure whole method, as well as to the pure part method. In addition to the above conclusions, several others were supported by a continuation of the experiments. Transfer factors, both general and specific, operate at their full value in the part method. The

law of diminishing returns holds in a maze of excessive length and difficulty; and the part methods aid in compensating for this factor. As regards the distribution of learning it was found that massing trials is highly unfavorable for the whole method; but all types of part method learning produced better results under massed conditions than whole methods under similar massed conditions. Finally, it was ascertained that learning a motor problem by the part method produces results that contradict the findings secured under similar conditions with rote and logical material. A second article by Pechstein (6) expresses in more concise form the conclusions reached by him as the result of this investigation.

The maze was used by Webb (9) as an experimental device for a comparative study of transfer and retroaction. The possibilities in the meaning of the two terms are defined in his preliminary statement; both of them may refer to positive or to negative effects, or to the absence of effect. Webb's first procedure was to divide his subjects, who had learned a maze (Maze A) into groups. One group was then asked to learn Maze B; another Maze C; and a third, Maze D. A similar program was put into effect with the rats. The results show transfer for all mazes for both humans and animals; moreover, this transfer was in evidence in all of the three measurements—error, time and excess distance. This is all the more significant inasmuch as Mazes A and B were designed to secure transfer effects, while the others were constructed to elicit negative transfer. While the net results were positive, negative effects were in evidence—transfer is a composite process, and the total result is determined by the predominance of one of the two elements. A third group of results deal with the degree of transfer. It is partly a function of the second learning activity, since the second problem varied with each group while the first (Maze A) was fairly constant. The activity acquired in the first problem also determines to an extent the degree of transfer, since the amounts saved in the second problem and the original learning records were roughly proportional. Again, transfer depends upon the amount of similarity in two mazes. The laws and conditions of transfer are essentially identical for both humans and the rats. The locus of transfer is on the average confined to the first five trials—the subjects saved in the second problem the equivalent of the first five trials of effort. Transfer operates more by reducing the tendency to retrace than by decreasing the tendency to enter cul-de-sacs. These results lead to a criticism of the transfer theories of both

Bagley and Thorndike; the maze learning activity, however, is too complex to afford an easy technique for an analysis of this phenomenon. The second part of Webb's experiment is devoted to a study of retroaction. More individual variation is in evidence in relearning a maze than in its original mastery. No correlation obtains between the learning and the relearning records. Humans show a slightly greater retentive ability in the maze activity than rats. The maze requiring the greater effort in learning is retained better than a maze calling for a lesser degree of effort. The results also show negative retroaction (retroactive inhibition). This is an individual matter, not a function of the maze itself. Humans are more likely to show retroactive effects than animals. A positive correlation exists between any two of the three criteria employed in measuring retroaction. A positive correlation holds between ease in learning a maze and the negative amount of retroactive influence, and a negative correlation between positive transfer and a negative retroaction. Two theories are suggested in explanation of retroaction. According to the Transfer Hypothesis, in a sequence of mazes learned, A-B-C, the effect is in terms of the transfer of the B habit to the relearning of A. According to the Disruption Hypothesis the B habit disrupts and disorganizes the relearning, or the second A habit. While the two are not necessarily antagonistic, the explanation is to be found chiefly in terms of transfer.

A comparison between two methods of learning the same material is made by Gray (3). The material used was an ingenious form of the substitution test. The subjects were required to translate twelve prose selections into code form. These selections were printed on the left margin of the sheet. The remainder of the sheet contained intersecting vertical and horizontal lines, the latter corresponding to the lines of the selection. The subject marked on each vertical line in order from left to right the symbols representing the letters of the printed line by a series of short dashes to the right and to the left of the vertical. The key consisted of the letters of the alphabet and corresponding numbers composed of the digits 1 and 2. The 1 meant a dash to left of the vertical line, and the 2, a dash to the right. The order in which the digits were given indicated the order in which the dashes were to be placed, from the top of the section of the vertical line to the bottom. Thus, *R*, 2111, was expressed by one dash to the right followed beneath by three to the left. The number combinations were made according to a definite, logical system. The test was given to two groups by two

different methods. In Method I the letters of the alphabet with their code numbers were printed at the top of the sheet; but they were arranged in irregular order, and the plan was not discovered by the subject. In Method II the plan was carefully explained, thus making the test a rational procedure. The results show that the upper limits of distribution, or the highest point in efficiency, was attained by individuals using each of the methods. However, the rational method makes for a wider range of distribution than the mechanical. The rational method also requires a greater initial period of adjustment before objective progress is in evidence, and this for some is a period of discouragement. As a check upon the interpretation of the results, three tests were given to individuals in both groups. These were the Thorndike Association Test, the span of attention and the tapping test. A good correlation was obtained between ability in the association test and in the original substitution test; but this correlation, though positive, was not so pronounced in the two remaining tests. In order to determine the importance of the motor aspects of the substitution test, forty subjects were given a series of tests in making horizontal marks on alternate sides of a vertical line. The correlations indicate that a considerable part of the learning is a motor function. An analysis of the error record in the substitution test shows that in the earlier part of the learning more errors were made by those employing the logical method than by those using the mechanical method; but the two methods produce about equal records in accuracy towards the end of the practice. Since the logical method required more mental work and resulted in more discouragement, the question of a compensatory effect for this method was investigated. Three devices for testing retention were employed, and it was found that the logical method results in a far greater amount of retention, presumably because it requires work of a higher mental level. The question of transfer was next investigated. Two substitution tests devised by Dearborn and Goddard were used for this purpose. The training resulting from the logical method permits greater transfer than a similar amount of practice with the mechanical method. In interpreting this fact in the light of different theories of transfer, Thorndike's theory of identical elements is inadequate because an equal number of common points is present in both cases. Bagley's theory of ideals is also unsatisfactory. Angell's theory of attention is more plausible, since a far greater premium was placed upon the attentive factor in Method II then in Method I. This,

combined with Judd's theory of generalization, seems best to explain the transfer effects found.

A comparison between normal and feeble-minded children as regards their ability in practice and transfer is reported by Woodrow, in two articles, (**10, 11**). Four groups were used, a normal practice and a control group of the two types of children respectively. The mental age of nine was the basis for the selection. The chronological age of the normal children was accepted as adequate for that group. The chronological age of the feeble-minded was slightly under fourteen. Practice consisted in sorting out the geometrical designs furnished by the Woodworth-Wells Substitution Test. These were pasted on gun wads and the wads were sorted into appropriate boxes. The number sorted per unit of time was used in determining the scores. It was found that the practice curves for both feeble-minded and normal children of the same mental ages are strictly comparable. Feeble-minded children show the same improvement with practice as the normal children. In both groups those ranking low in initial ability improve relatively more than those ranking high; in absolute terms, children of both groups improve to about the same extent. Feeble-minded children show a slightly greater tendency towards irregularity, but the difference is less than the probable error of the difference, and therefore is not of consequence. The assumption that feeble-minded children are not capable of improving with practice to the extent that normal children of the same mental age is made because of the erroneous tendency to identify capacity for mental development with ability to gain with practice. It is not inability to learn that characterizes incapacity for mental development, but inability to grow. The experiment was continued for the purpose of determining the effects of transfer. The tests used were sorting sticks of varying lengths, sorting colored pegs, a letter and a form cancellation test. The instructions emphasized speed. A comparison of the transfer effects was made by repeating these tests with the control groups after an interval of time. Again the results indicate great individual differences in improvability for each group but no difference of significance between the two groups as regards transfer. The general conclusions suggested by the first part of the experiment are confirmed by the part dealing with transfer. Feeble-minded children, averaging in age fourteen chronologically and nine mentally, may be regarded as arrested in mental growth. Normal children of the same chronological and mental age in all

likelihood will continue to grow mentally. It is not inferior ability to learn that keeps the feeble-minded children from becoming normal. The possibility of lack of retentive ability is suggested, but the difference in memory between feeble-minded and normal children does not justify the acceptance of this explanation. The results of the experiment do not answer the question in positive terms. Absence of capacity for growth seems to be the distinguishing factor between the normal and the feeble-minded child.

Myers (4) reports the results of an investigation of correlations in learning. These are concerned with the relationship between initial and subsequent performance, the tendency of practice to bring individuals more closely together or to separate them, the relationship between card sorting and intelligence and improvement in card sorting as an index of intelligence. In card sorting, the individuals tend to maintain the same relative position during the learning. Stated in more concise terms, the first five trials are representative of their learning processes. However, factors in addition to capacity for the task enter into the learning. The subjects who were informed of the differences in the rate of progress of the various learners manifested a greater tendency to shift than those who were not so informed. As regards the relationship between card sorting and intelligence, no correlation obtains; but gain in card sorting shows a positive correlation with intelligence. This supports the tendency to define intelligence in terms of capacity for improvement. On the basis of other correlations the author concludes that the performers who attain the highest place tend to gain most, and that the performers who reach the highest point tend to end best. The question of the tendency of practice to make individuals in the group more homogeneous cannot be answered in either positive or negative terms. Finally, no correlation holds between irregularity and gain in performance.

Thurston's method of calculating learning curve coefficients is criticized in a short article by Blair (1). The claim is made that the equation breaks down in use because of no known method of estimating the zero point. This would result in a child with *n* amounts of practice being credited with less previous practice than the child with *o* practice. Furthermore, since there are differences in the rate of learning it is impossible to compare a segment of one curve with a segment of another. The true zero point in learning must be discovered before any learning curve equation can be employed.

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THOUGHT AND THE HIGHER MENTAL PROCESSES

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Continuing a study, reported several years ago, which shows that good visualizers do not differ appreciably from poor visualizers in the accuracy of their judgments of numbers or magnitudes from memory, Thorndike (5) investigated the question of whether the same holds good when the judgments are of *relative* magnitude or proportion. About 300 students were asked to judge from memory what per cent. the length of a certain building is of the total width of the square on which it stands. The errors made by the poorest third of the visualizers were only slightly in excess of those made by the best third.

In multiplying mentally three place by two place numbers, the best visualizers made a median time of 480 seconds with 5 as the median number of mistakes. The corresponding numbers for the poor visualizers were 500 and 6.

Basing his conclusion on a coefficient of correlation, Thorndike

found that ten reports of visualization will give practically as good a result as an infinite number of reports.

Parsons (3) found no marked difference between the imaginative reaction of children (52 boys and 45 girls aged 7–7 1/2) and adults toward ten standardized ink-blots. Children, like adults, are most interested in animals and other living things. Boys of seven are more interested in war than girls of the same age, while girls seem to have a keener interest in domestic animals. There is a marked preponderance of nonconstructive associations, as "lady dancing," "a broken sledge." A tendency toward active imagination is indicated by a frequent active search for associations.

Using simple drawings of circles, triangles and straight lines with the hand out of sight, accompanied by introspective records, and with four psychologists as subjects, Metcalf (2) attempted to ascertain whether certain regular bodily reactions accompany the attitude of certainty and uncertainty. He found that there is a correlation between the conscious attitudes and the objective form of the reaction as measured by its accuracy, rate and pressure. Accuracy of the drawing is less important than the other characteristics for the appearance of certainty; in some cases greater accuracy and certainty go together, but more frequently they do not. In relation to the time element, certainty is usually found with a faster, and especially an accelerated, rate of drawing. In most cases, also, certainty is found to be correlated with a definite type of pressure curve, and uncertainty with a deviation from that type.

Restricting himself to the sense of touch, Bonaventura (1) reports an experimental investigation on thought activity in sensorial perception. Little, if anything, beyond the well known associative processes active in perception, is revealed. Space perception by touch is said to be the result of the elaboration of sensations by thought, which takes note of certain characteristics, distinguishes them and places them in certain relations, one to another. These are associated with relations of space derived from muscular and articular sensations connected with motions and with sensations from sight.

Under the title "How far can ideas influence peripheral processes?" Solomon (4) discusses the possible peripheral changes producible by hypnotism, presenting the best authentic evidence for and against bodily or peripheral effects of hypnotism. He emphasizes the necessity of clearcut differentiation between the

ideational processes and those of emotional origin, concluding that much of the claimed production of peripheral sensory effects by hypnotic influence is due to a confusion of the ideogenetic and emotogenetic processes. He next discusses the claims made in psychopathology, concluding that many of the claims of peripheral effects are not valid, but are due to a disordered functioning of the involuntary and voluntary nervous systems. Among the conclusions he comes to are: ideas can lead to functioning of the voluntary nervous system but cannot, in a direct manner, produce activity of a sensory nature. Hence, hallucinations of any kind cannot be due directly to ideas. Ideas cannot directly produce, or call into being, pains of a true type. Ideas cannot directly affect the peripheral processes wholly under the domination of the involuntary nervous system, although they can indirectly affect the involuntary system by exciting the emotions.

Whitehead's (6) *The Organization of Thought* is pedagogical rather than psychological in its nature. The book takes its title from one of a series of eight relatively independent papers and addresses. Organized thought is made to be synonymous with science and is recognized as the basis of organized action. Science is rooted in common sense thought: this is the *datum* from which it starts and to which it must recur. Formal, traditional logic is criticised, but "logic properly used, does not shackle thought. It gives freedom, and above all, boldness." The induction of valid generalizations should be made the keystone of logic and to this deduction should be in the main tributary.

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NOTES AND NEWS

The Summer Training School of Psychiatric Social Work conducted by the Boston Psychopathic Hospital and Smith College under the auspices of the National Commiteee for Mental Hygiene opened at Smith College July 7th with an enrollment of 68 young women from 21 states and as many colleges. The purpose of the school was to give in eight weeks the theoretical background necessary to prepare social workers to assist in the rehabilitation of soldiers suffering from "shell shock" and other nervous and mental disorders.

The temporary officers of the American Association of Clinical Psychologists have deemed it advisable to cancel the annual meeting scheduled for December, 1918. The temporary officers of the Association are as follows: Chairman, J. E. Wallace Wallin. Secretary: Leta S. Hollingworth. Committee on constitution: Leta S. Hollingworth, David Mitchell and Francis N. Maxfield. Committee on nomination of officers and new members: Rudolf Pintner, Helen Thompson Woolley and H. H. Goddard. Committee on program for the next meeting: the chairman, secretary and the committee on constitution. (Later: The action of the officers has been rescinded, and it has been decided to hold an informal meeting at Baltimore at the time of, or following, the meeting of the American Psychological Association.)

Joseph Peterson (Ph.D., Chicago, 1907), assistant professor of psychology in the University of Minnesota and chairman of the department for 1918–1919, has resigned to accept a professorship of psychology in George Peabody College for Teachers, Nashville, Tenn.

The Council of the American Psychological Association has decided to hold the regular meeting of the Association in Baltimore during the Christmas holidays. The papers to be presented will deal largely with the relations of psychology to Army activities.